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GEOPHYSICAL VARIABLES AND BEHAVIOR: III. PREDICTION OF UFO REPORTS BY GEOMAGNETIC AND SEISMIC ACTIVITY

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Summary.—Multiple regression analyses were used to test the hypothesis that UFO (unidentified flying object) reports are indices of natural events associated with accumulating tectonic strain within the earth's crust. More than 80% of the variance in a sample of UFO report numbers within the central and eastern U.S.A. between the years 1950 and 1966 could be accommodated by entering the appropriate three to five measures of geomagnetic or seismic activity of the previous one to three years. In general, UFO report numbers tended to increase two to three years after decreases in geomagnetic activity and the year after increases in the number of local, low intensity earthtremors. Predicted UFO report numbers within these regions were also determined from the equations for the years 1967-1981.

Odd lights in the sky are frequent stimuli that evoke clear behavioral changes in human populations. These stimuli have been called odd meteors, airships, flying wheels, fireballs, ghosts, spirits, and (more recently) UFOs or unidentified flying objects. In many parts of the world, clusters of UFO events appear to occur months to years before certain types of earthquake activity. UFO clusters in the central and eastern U.S.A., for example, display correlations of 0.7 to 0.8 with seismic activity a few months to a year later in these regions (Persinger, 1980a, 1980b).

One hypothesis (Persinger, 1976, 1979) predicts that UFOs are energetic (and potentially hazardous) natural phenomena generated by as yet unspecified processes associated with tectonic strain. Factors that influence this strain, which may exist for several months to years before an actual earthtremor or earthquake, would influence the probability of UFO events. These factors, whether local or far-field stresses, would be determined by the temporal and spatial increment of analyses. At the level of large space, for example, the central U.S.A., and large time (1-yr. increments), these factors would involve solar-geomagnetic variables as well as recent earthquake history.

Although UFO displays should primarily precede increased earthquake activity (the actual latency varying for different tectonic regions and for different earthquake intensities), preliminary multiple regression analyses indicated that some prediction could be possible. Increased UFO activity appeared to increase one to three years after a *decrease* in: (1) geomagnetic

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(or solar) activity, and (2) the occurrence frequency of the most correlated seismic intensity, but an *increase* in the numbers of microseisms or small earthtremors. To test the limits of the model for prediction, the following series of analyses were completed. All analyses were completed using a DEC 2020 computer and SPSS software.

Yearly totals of UFO clusters (or "flaps") for the 17 yr. between 1950 and 1966 were sorted from the master file (Persinger & Lafrenière, 1977) for the central (CUFO) and eastern (EUFO) sectors (Persinger, 1980a) of the U.S.A. All reports had been published in *Fate* magazine as major events (multiple witnesses) and had been corrected for redundancies and for spatial/temporal loadings according to previous methods (Persinger, 1980b). These years were selected since: (1) systematic coverage of UFO reports by *Fate* begins after 1949 and (2) after 1966 the total reports in the file begin to decrease abruptly as the file end (1970) is approached. During the analysis period, the central and eastern sectors displayed totals of 140 and 74 UFO reports, respectively.

Yearly totals for the different intensity earthtremors or earthquakes (MM or Modified Mercalli Scale) for each sector were determined for intensities $\leq$ III, IV, V, and $\geq$ VI from the early U.S. Earthquake (U.S. Department of Commerce) publications. These variables were called CQLO, CQIV, CQV, and CQLA, respectively, in the central sector, and EQLO, EQIV, EQV, and EQLA, respectively, in the eastern sector. Total values (TQCE and TQEA) for total seismic events and for the intensities IV and V combined (CQ45T and EQ45T) were also calculated. A "power" measure for each sector was determined in the following manner:

$P = (2 \times \text{QLO}) + (3.5 \times \text{IV}) + (4.0 \times \text{V}) + (4.5 \times \text{VI}) + (5.0 \times \text{VII or greater})$.

Yearly means of the monthly means for the A_P index (APA) and the yearly means for the mean monthly Zurich sunspot numbers were obtained from the *Journal of Geophysical Research*. A measure of dispersion for the geomagnetic measure, the standard deviation of the monthly A_P indices around the yearly means, was called APSD. Since the sunspot number range approached 10^3, the square root of the sunspot numbers (SSS) were used throughout the study.

Because the number of cases (years) involved is relatively small, special care was taken to attenuate the effects from outliers and other distribution peculiarities. The means, standard deviations, and skewness measures for the variables are shown in Table 1. To determine the effect of data transformations and to reduce skewness: (1) outliers of *only* variables with skewness values greater than 1.00 were recoded and (2) square roots were calculated for *all* (except SSS) the variables.

TABLE 1

MEANS (*M*), STANDARD DEVIATIONS (*SD*), AND SKEWNESS (SK) VALUES OF THE VARIOUS UFO, EARTHTREMOR AND SOLAR-GEOMAGNETIC MEASURES FOR THE RAW, RECODED, AND SQUARE ROOT TRANSFORMED DATA

Measure	Raw Data			Recoded Data			Square Root Data		
	M	*SD*	SK	*M*	*SD*	SK	*M*	*SD*	SK
CUFO	8.2	6.9	1.2	7.2	4.7	–0.1	2.6	1.3	–0.1
EUFO	4.3	3.3	0.6				1.8	1.0	–0.5
CQLO	1.1	1.3	1.2	1.0	1.1	0.7	0.8	0.7	0.2
CQIV	3.0	2.7	1.7	2.8	2.2	0.8	1.5	0.8	0.0
CQV	2.7	2.3	0.6				1.4	0.8	–0.2
CQ45	5.7	3.6	0.3				2.2	0.9	–0.7
CQLA	1.7	1.2	1.2	1.6	0.9	0.4	1.2	0.5	–0.9
CQTO	8.5	4.3	0.5				2.8	0.8	–0.1
CQPO	31.4	15.4	0.3				5.4	1.8	–0.3
EQLO	2.2	3.4	2.2	1.8	2.3	0.8	1.0	1.1	0.7
EQIV	1.7	1.7	0.8				1.0	0.9	0.0
EQV	1.3	1.2	0.2				0.9	0.7	–0.4
EQ45	2.9	1.9	0.4				1.6	0.7	–1.1
EQLA	0.8	1.4	1.6	0.5	0.8	1.1	0.5	0.8	1.1
EQTO	6.0	3.6	1.2				2.3	0.7	0.2
EQPO	19 1	9.8	0.1				4.2	1.3	–0.4
SSS	8.0	3.6	0.0						
APA	16.5	4.3	0.1				4.0	0.6	–0.2
APSD	4.5	2.3	0.9				2.2	0.5	–0.3

In the first instance, outliers (those in the upper 5% of the population) were recoded to a value of the 95th percentile plus the square root of the difference between the former and the score. For example, the CUFO distribution ranged from 0 to 10 except for two years where the total values were 20 and 28. With this procedure, the two years (only) were recoded to 13 and 14, respectively. As can be seen in Table 1, both this procedure and the complete square root transformation attenuated skewness. (Since the skewness of EQLA only was not reduced below 1.0 by any of the data transformations, a new variable EQME (EQLA + EQV), which was normally distributed, was compared when EQLA entered an equation.)

Simple correlation matrices demonstrated that the relationships between the *Fate* UFO data and earthquake numbers were similar (adjusting for the 1-yr. increment of analyses) to previous reports (Persinger, 1980a). CUFO numbers were most correlated with TQCE (0.52) and CQIV (0.52) earthquakes of the same year periods. EUFO numbers were most correlated with EQLA (0.58) and TOQE (0.60) numbers 2 yr. later. Increased EUFO numbers were also evident during the year (0.57) and the year before (0.50) increased CQIV activity. The highest correlation (0.85) between EUFO and

CUFO occurred during the same year. The relationships were persistent in all three data sets.

The primary analyses involved step-wise multiple regression. For each dependent variable (either CUFO or EUFO), the following combinations of lagged independent variables were allowed to enter: (1) intensity $\leq$ III, IV, V or $\geq$ VI quakes from the same sector, (2) all quakes from both sectors, (3) $\leq$ III IV + V, or $\geq$ VI quakes from the same or all sectors, (4) geomagnetic-solar variables only, (5) either conditions 1, 2, or 3, with solar geomagnetic variables, and (6) solar geomagnetic variables with either total earthquake numbers or total power measures from each or both sectors.

Each variable was lagged from 1 to 3 (a total of 3 variables for each source variable). A lag of 1 indicates that the data for a given variable from the previous year were entered into the equation. In the first series of analyses, only one lag for each variable was allowed to enter the final equations. If more than one lag of the same variable entered, the regression procedure was repeated by including only the first lag of that variable to enter, along with the other appropriate variables. Since the possibility did exist that the processes involved with UFO events could be trigonometric, for example, the occurrence of UFOs might be related to the same variable lagged 1 yr. and 3 yr. before (but with no intercorrelations), a second series of analyses were conducted that allowed the inclusion of the two most powerful lags for each variable. Regardless of lag inclusion, no more than the first 5 (significant) variables were used for the equations (usually the change in r^2 for each of the remaining variables was less than 2% anyway).

As extra precautions and to compare the effects of data transformations, the above procedures were completed for all three data sets: raw, recoded, and square root. Once the basic equations were determined, related variables were substituted (e.g., SSS for APA) to determine the degree of alteration. Usual determination of intercorrelations between independent variables and tests for autocorrelation (Durbin-Watson) were completed. In addition, to control for temporal artifacts (simple change in UFO reports with time *per se*), a variable of case sequence (seqnum) was also tested within the final equations.

The optimal equations (maximum multiple r^2) for the prediction of either CUFO or EUFO events are shown in Tables 2 and 3. For each equation, the various independent variables (lag years in parenthesis), their partial regression coefficients (B) and their standard errors (SE_B) are specified. The following equation data are also given: the constant, the multiple r (MR), the *modified* multiple r-squared (MMRS), the standard error of the estimate for the equation (SE_E), the F ratio (F), the results of the Durbin-Watson test (D-W), and the greatest intercorrelation between the independent variables (GIC). Equations A to C involved the recoded data while Equations D and E involved the square root and raw data, respectively.

TABLE 2

OPTIMAL EQUATIONS FROM DIFFERENT DATA SETS FOR PREDICTION OF UFO NUMBERS WITHIN CENTRAL U.S.A. (SEE TEXT FOR DESCRIPTIONS)

Measure	CUFO (A) (Quakes Only)	CUFO(B) (All Variables)	CUFO(C) (Conditional)	CUFO(D) (SQRT)	CUFO(E) (Raw Data)
X_1	EQIV1	APA3	APA3	APA3	APA3
$\beta(SE_B)$	1.58 (0.40)	−1.02 (0.11)	−0.77 (0.07)	−2.03 (0.32)	−1.27 (0.18)
X_2	EQLA3	SSS2	SSS2	SSS2	CQLA1
$\beta(SE_B)$	−1.05 (0.46)	−0.47 (0.11)	−1.07 (0.12)	−0.16 (0.04)	2.68 (0.53)
X_3	EQV3	CQLO2	APA1	EQLO3	CQLO2
$\beta(SE_B)$	−2.67 (0.69)	0.83 (0.27)	0.52 (0.09)	0.45 (0.13)	0.81 (0.25)
X_4	EQLO2	CQLA3	CQLO1		CQ4T3
$\beta(SE_B)$	−0.87 (0.24)	−1.58 (0.49)	0.46 (0.16)		0.52 (0.24)
X_5	CQLA3	CQ4T3			
$\beta(SE_B)$	−1.09 (0.59)	0.57 (0.23)			
Constant	11.92	27.87	20.15	11.63	22.88
MR	0.89	0.95	0.95	0.91	0.94
MMRS	0.70	0.87	0.93	0.80	0.84
SE_E	2.55	1.67	1.21	0.61	2.73
F	8.43	22.54	55.76	20.49	22.17
Durbin-Watson	2.00	2.29	2.20	2.21	1.69
GIC	0.41	0.69	0.75	0.45	0.38

TABLE 3

OPTIMAL EQUATIONS FROM DIFFERENT DATA SETS FOR PREDICTION OF UFO NUMBERS WITHIN EASTERN U.S.A.

Measure	EUFO(A) (Quakes only)	EUFO(B) (All Variables)	EUFO(C) (Conditional)	EUFO(D) (SQRT)	EUFO(E) (Raw Data)
X_1	EQM2	SSS3	EQV2	SSS3	APA3
$\beta(SE_B)$	−0.86 (0.34)	−0.82 (0.12)	−1.52 (0.43)	−0.19 (0.04)	−0.55 (0.12)
X_2	EQIV1	CQLO2	CQLA1	EQV2	CQLO2
$\beta(SE_B)$	1.28 (0.42)	0.75 (0.16)	1.24 (0.34)	−1.01 (0.22)	0.57 (0.20)
X_3	EQLO1	EQIV1	EQV3	CQV3	CQV3
$\beta(SE_B)$	0.86 (0.30)	1.18 (0.26)	−2.38 (0.57)	−0.30 (0.15)	0.51 (0.19)
X_4	CQLA2	CQIV1	CQLO1	EQLA3	EQIV1
$\beta(SE_B)$	0.96 (0.50)	−0.57 (0.17)	−0.75 (0.22)	0.50 (0.23)	0.62 (0.31)
X_5		EQLO1	CQV1	CQIV3	CQV1
$\beta(SE_B)$		0.46 (0.13)	−0.73 (0.23)	−0.26 (0.16)	−0.34 (0.27)
Constant	0.44	8.56	9.39	4.71	11.00
MR	0.81	0.94	0.90	0.91	0.89
MMRS	0.53	0.83	0.71	0.76	0.69
SE_E	2.27	1.37	1.79	0.48	1.86
F	5.57	16.66	8.83	10.87	7.97
Durbin-Watson	1.87	2.37	2.78	2.77	2.48
GIC	0.60	0.54	0.38	0.52	0.60

The first equations, CUFO(A) and EUFO(A), involve the maximum prediction with quake data (both sectors) only. As can be seen, only 53% to 70% of the variance in UFO numbers can be accounted for by antecedent earthquake activity. The general trend involved a negative slope for earthquake numbers of all the different intensities except for CQLO in the central region and EQIV in the eastern sector. These intensity quakes usually increased during the year before the increase in UFO reports. This observation was repeatedly evident in those equations (not shown) involving quakes of the *same* sector only.

The introduction of solar-geomagnetic variables into the equations elevated the explained variability in both sectors. More than 80% of the variance in the report of UFO events could be accounted for by the three to five antecedent solar-geomagnetic and seismic measures. The predictions were most impressive ($MR = 0.95$) for the conditional equation, CUFO(C). Interestingly, the intercorrelation between the two APA lags was 0.01; the 0.75 intercorrelation was between SSS2 and APA1. (Addition of the seqnum variable to check for temporal artifacts did not alter the contribution of any variable in any of the equations).

The importance of the A_P index (or the square root of the sunspot numbers) 3 yr. before the observations is evident in all three data sets for both sectors. Earthquake intensities demonstrated less systematic entries. Whereas CQLO2 and CQ4T3 were important in both recoded and raw data, they were not important for the square root data. Little consistency existed for the earthquake entries in the eastern sector.

Such alteration in quake intensity entry may reflect aspects of the empirical approach (optimal entry of quake intensities) rather than the limits of the theory. If only APA (or SSS) indices of low level activity (IV for the eastern and $\leq$ III for the central sector), and the optimal quake correlation (IV for central and LA for the eastern sectors) were used, the *MR*s still exceeded 0.80, regardless of data set.

Neither total (CQTO, EQTO) nor "power" (CQPO, EQPO) measures of earthquake activity added to the predictions. In fact, the entry of yearly total seismic activity actually reduced the amount of explained variability (even when the number of lagged variables for total activity was equal to the number of different intensity quakes in the equations). This result suggests that the dynamic pattern between different intensity tremors may be a more critical indicator of consequent UFO numbers than total seismic displays. Different tectonic regions would be expected to show different optimal dynamic patterns.

Predicted UFO event numbers (for both the recoded and square root, data sets, i.e., the B and D equations in Tables 2 and 3) in the central and

eastern U.S.A. for the years 1950 to 1981 are presented in Fig. 1. For comparison, observed values for the years 1950 to 1966 (from which the equations were determined) are also given. Both data sets in both sectors demonstrated good agreement for the predicted high and low UFO report years. The confidence interval estimates can be determined from the UFO means of the different populations (Table 1) and the SE_E of the equations in Tables 2 and 3.[3]

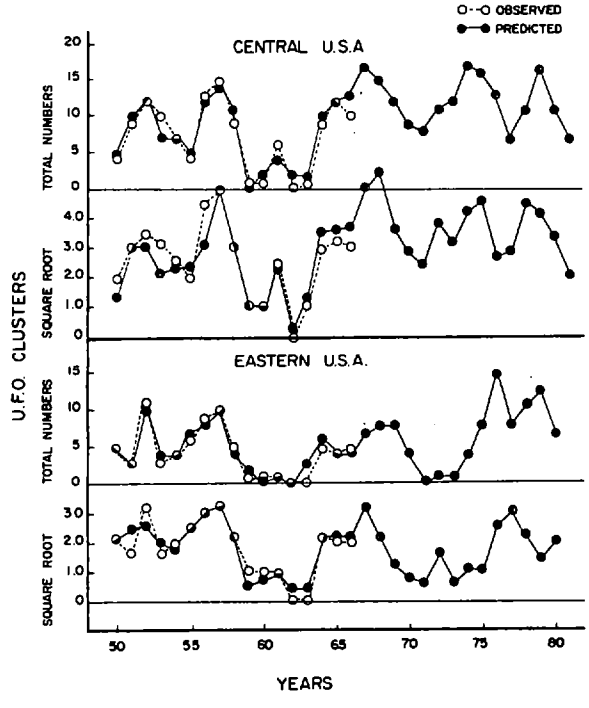

FIG. 1. Observed (open circles) and predicted (closed circles) for the total numbers and square roots of the total numbers of UFO cluster reports in the central and eastern U.S.A. for the years 1950 to 1981

The next step is to determine the resolution capacity of the model by predicting UFO reports within smaller spaces and within briefer increments of time. More precise earthquake magnitude measures (rather than crude intensity estimates) and other indices of strain (including *change* in earth-tremor activity over time and harmonics) must still be tested. Several UFO data sources as well as different types of reports remain to be compared. All

[3]Further analyses using 6-mo. intervals (and so twice the number of cases) demonstrated the importance of the same variables at comparable lags. Values of multiple correlation still exceeded 0.80.

of these procedures *assume*, it must be remembered, that there is a systematic relationship between the numbers of UFO reports and the numbers of UFO events (which the hypothesis, in a technical sense, is predicting).

Unlike most UFO explanations, the present theory indicates that predictions of UFO events are possible by (1) emphasizing the spatial and temporal distributions of UFO report numbers (rather than a few exotic case histories), (2) assuming the source stimuli to involve measurable, physical processes, and (3) using routine multivariate procedures. At present, it should be considered as an illustrative case rather than a proof. However, even simple solutions remain obscure if they are never tested.

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